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(71) Applicant: SPECTRUM SCIENCES B.V. [NL/NL]; Coolsingel 101, P.O. Box 21236, NL-3001 AE Rotterdam (NL).

(72) Inventors: LEVY, Uri ; 5 Einstein Street, 76 100 Rehovot (IL). GOLDNER, Eduard ; 12/49 Kadish Luz Street, Ramat Sharet, 91 999 Jerusalem (IL). NIV, Yehuda ; 7/4 Shderot Chen, 76 100 Rehovot (IL).

(74) Agents: DE BRUIJN, Leendert, C. et al.; Nederlandsch Octrooibureau, Scheveningseweg 82, P.O. Box 29720, NL-2502 LS The Hague (NL).

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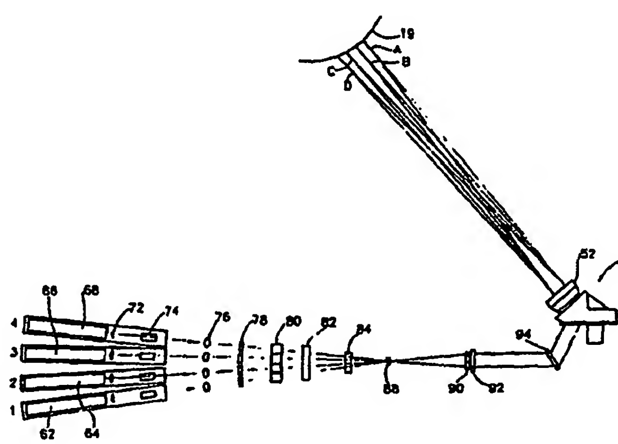

(57) Abstract

A compact multi-beam laser scanning system having a large bandwidth which is capable of being modulated at a high information rate. The multi-beam laser scanning system is applicable to a wide format, high resolution, high speed electrophotographic printing process and comprises apparatus for producing a plurality of modulated laser beams; multiple beam combiner apparatus disposed so as to have each of the beams incident thereon for combining the plurality of modulated beams to provide a plurality of output beams which are commonly aligned in a plane and have a fixed angular separation therebetween; and deflection scanning and focusing apparatus for providing the comm nly aligned and angularly separated output beams with a scanning motion on an image plane.

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MULTI-BEAM LASER SCANNER SYSTEM

FIELD OF THE INVENTION

The present invention relates to light beam scanning apparatus, and more particularly, to a large bandwidth multi-beam laser scanner useful in a wide format, high resolution, high speed printing process.

BACKGROUND OF THE INVENTION

It is known in the prior art to use light beam scanning in printing processes on film, electrophotographic printing, inspection systems, information retrieval from memory and display systems.

In a printer using an electrophotographic printing process, it is known to use laser scanners for "writing" the latent image on a photoconductor. The laser scanning beam is typically modulated by an acousto-optic modulator which can handle limited bandwidths. The bandwidth sets an upper limit to the information rate, and this determines the scanning speed for a given scan path width in the image plane, and also determines the process speed.

The largest bandwidth laser printing system available on the market today provides a scanning speed of 30 Mpixels per second. In addition to the bandwidth limitation, another limitation in the use of a single scanning beam to achieve a given process speed is the limited rotation rate of the mechanical spinner used to provide beam deflection. The solution to both these limitations is to use a multi-beam scanner configuration.

A known optical configuration for a multi-beam photoscanner is disclosed in US Patent 4,637,679 to Funato, wherein a polarization beam combiner is used to combine two polarized laser beams which are then deflected by a rotating hologram disc. Since the hologram diffracts each polarization differently, the power of the diffracted beams reaching the image varies with the scan angle.

Another known multi-beam deflection arrangement is discl sed in US Patent 4,444,470 to Ioka t al, wherein a

single acousto-optic modulator is used to generate and modulate multiple laser beams. The single acousto-optic modulator has a limited bandwidth and low diffraction efficiency meaning that a high power laser is required. Also, use of multiple frequency drivers for multiple frequency modulation complicates the arrangement.

Also known in the prior art of laser scanning is the use of a rotating holographic element, known as a hologon, for providing scanning beam deflection with reduced wobble, as disclosed in US Patent Nos. 4,239,326, 4,289,371 and 4,304,459, all of which were issued to Kramer. Used with laser line scanners which generate a repetitive single scan line, this approach minimizes cross-scan position errors in the scanning beam and avoids the need for corrector optics, as opposed to another known approach which uses a rotating polygonal mirror element.

In Japanese Published Patent Application 59-29221 there is described a multi-beam hologram light scanner wherein the beams are independently generated and combined by a plurality of light fibers into a linear scanning array arranged perpendicular to the scanning direction. In one embodiment the array comprises a double row of light fibers in a mutually offset arrangement, permitting scanning overlap.

In Japanese Published Patent Application 62-257267 there is described an image recording device wherein a semiconductor laser array with a plurality of light emitters scans a photosensitive medium to record an image in an image recording device which is characterized by the distance between laser beams from adjacent light emitters being 28 times the line spacing.

In applications calling for a wide format, high resolution, high speed printing process, there are presently no compact laser scanning systems which meet the bandwidth requirements dictated by a high information rate.

U.S. Patents 3,907,423; 4,068,938; and 4,264,185 and 4,562,129 show apparatus which is related to the subject matter of the present invention.

SUMMARY OF THE INVENTION

Accordingly, it is a principal object of the present invention to overcome the above-described disadvantages and limitations and provide a compact multi-beam laser scanning system having a large bandwidth which is capable of being modulated at a high information rate. The laser scanning system is applicable, inter alia, to a wide format, high resolution, high speed electrophotographic printing process.

There is thus provided in accordance with a preferred embodiment of the present invention a multi-beam laser scanning system comprising apparatus for producing at least three non mutually planar laser beams, multiple beam directing apparatus receiving the at least three non mutually planar laser beams for providing a plurality of output beams which lie in a plane and have a fixed angular separation therebetween and apparatus for providing a scanning motion to the plurality of output beams.

There is also provided in accordance with a further preferred embodiment of the present invention a multi-beam laser scanning system comprising apparatus for producing a plurality of laser beams, apparatus for separately modulating each of the plurality of laser beams, and holographic scanning apparatus for receiving the plurality of laser beams following modulation thereof and for providing focused scanning of the laser beams across an image plane in a first direction, the plurality of laser beams being scanned lying in a plane perpendicular to the first direction and being arranged such that multiple scans produce an overlapping interlaced scan pattern.

There is further provided in accordance with still a further preferred embodiment of the present invention a multi-beam laser scanning system comprising apparatus for producing a plurality of laser beams, multiple beam directing apparatus receiving the plurality of laser beams for providing a plurality of output beams which lie in a plane and have a fixed angular separation therebetween, and

scanning apparatus for receiving the plurality of laser beams and for providing scanning thereof across an image plane in a first direction, the plurality of laser beams being arranged such that multiple scans produce an interlaced scan pattern wherein no more than five scans are required to fill a field.

In a preferred embodiment of the invention the apparatus for producing comprises a plurality of laser beam sources aligned in a common first plane. The plurality of laser beam sources may comprise continuous lasers and may be laser diodes.

Further in accordance with a preferred embodiment of the present invention, the means for producing also comprises a plurality of acousto-optic modulator means, each of which is arranged for operation with a respective one of the laser beam sources.

Still further in accordance with a preferred embodiment of the present invention, the means for producing also comprises a plurality of electro-optic modulator means, each of which is arranged for operation with a respective one of the laser beam sources.

Additionally in accordance with a preferred embodiment of the present invention, the means for producing also comprises a plurality of total internal reflection modulator means, each of which is arranged for operation with a respective one of the laser beam sources.

Further in accordance with a preferred embodiment of the present invention, the means for producing comprises a plurality of light valve modulator means, each of which is arranged for operation with a respective one of the laser beam sources.

Still further in accordance with a preferred embodiment of the present invention, the multiple beam directing means comprises a combiner disposed so as to have each of the laser beams incident thereon at an individual surface thereof, whereby the laser beams ar combined such

that they are commonly aligned with a fixed angular separation therebetween.

Additionally in accordance with a preferred embodiment of the present invention, the surface is prismatic and the modulated beams are combined by refraction.

Further in accordance with a preferred embodiment of the present invention, the surface is provided by a grating element and the modulated beams are combined by refraction.

Still further in accordance with a preferred embodiment of the present invention, the combiner means comprises a plurality of mirrors.

Additionally in accordance with a preferred embodiment of the present invention, the plurality of mirrors are stacked vertically one upon another, one for each of the beams, each of the mirrors being oriented about a central axis with a different horizontal angle, such that the beams are combined as output beams in a single plane and have their optical paths aligned with one another for tracing the scanned lines in the image plane substantially without separation between them along the scan direction.

Still further in accordance with a preferred embodiment of the present invention, the system further comprises telescope means disposed so as expand each of the output beams and reduce the fixed angular separation therebetween.

Additionally in accordance with a preferred embodiment of the present invention, the scanning means comprises a hologon disk scanner and the system also comprises focusing means including an f-theta lens.

In accordance with a further preferred embodiment of the present invention, there is provided a compact writing head for use in electrophotographic printing comprising an image bearing surface having a width of at least 30 inches and means for providing an image on the image bearing surface at a speed of at least 10 feet per minute with a r s lution f 400 d ts/inch including means for producing at

least three non mutually planar laser beams, multiple beam directing means receiving the at least three non mutually planar laser beams for providing a plurality of output beams which lie in a plane and have a fixed angular separation therebetween, and means for providing a scanning motion to the plurality of output beams.

In accordance with still a further preferred embodiment of the present invention, there is provided a compact writing head for use in electrophotographic printing comprising an image bearing surface having a width of at least 30 inches and means for providing an image on the image bearing surface at a speed of at least 10 feet per minute with a resolution of 400 dots/inch including means for producing a plurality of laser beams, means for separately modulating each of the plurality of laser beams, and holographic scanning means for receiving the plurality of laser beams following modulation thereof and for providing focused scanning of the laser beams across an image plane in a first direction, the plurality of laser beams being scanned lying in a plane perpendicular to the first direction and being arranged such that multiple scans produce an overlapping interlaced scan pattern.

In accordance with yet a further preferred embodiment of the present invention, there is provided a compact writing head for use in electrophotographic printing comprising an image bearing surface having a width of at least 30 inches and means for providing an image on the image bearing surface at a speed of at least 10 feet per minute with a resolution of 400 dots/inch including means for producing a plurality of laser beams, multiple beam directing means receiving the plurality of laser beams for providing a plurality of output beams which lie in a plane and have a fixed angular separation therebetween, scanning means for receiving the plurality of laser beams and for providing scanning thereof across an image plane in a first direction, the plurality of laser beams being arranged such

that multiple scans produce an interlaced scan pattern wherein no more than five scans are required to fill a field.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention with regard to the embodiments thereof, reference is made to the accompanying drawings in which like numerals designate corresponding elements or sections throughout:

Fig. 1 is an overall perspective view of an electrophotographic printing system incorporating a writing head based on the multi-beam laser scanner of the present invention;

Fig. 2 is a schematic representation of a marking engine portion of the printing system shown in Fig. 1;

Fig. 3 is a schematic representation of a preobjective hologon scanner used to provide a scan line in the image plane of the marking engine portion of Fig. 2;

Fig. 4A is a top view of an optical system layout for providing the multi-beam laser scanner in the writing head of Fig. 1;

Fig. 4B is a side view of an alternative optical system layout for providing the multi-beam laser scanner in the writing head of Fig. 1;

Fig. 5 is a perspective view of the vertical combiner used in the optical system layout of Fig. 4;

Fig. 6 is a side elevation of the optical system layout of Fig. 4 as viewed in the direction of arrows I-I, showing the hologon laser scanner-focusing subsystem;

Fig. 7 is a detailed schematic drawing of the laser-scanner focusing subsystem of Fig. 6; and

Fig. 8A is a perspective view showing a staggered tracing pattern for the scan lines to insure adequate vertical separation in the image plane of the marking engine portion of Fig. 2.

Fig. 8B is a chart showing image line writing for a separated scanning scheme.

photoconductive drum 19 along an imaginary circumferential line thereon and together scan along a plurality of spaced parallel scan lines across the drum between limits 26.

In accordance with the principles of the present invention, writing head 24 is provided in a compact arrangement for an electrophotographic printing process having a wide format and requiring high speed and high resolution. Using the individual laser sources to the generate the laser scanning beams in the multi-beam laser scanner arrangement provides multiple information channels, which enable the large bandwidth requirement in such a process to be easily accommodated.

As described further herein, the compact design is achieved by an optical layout in which four laser sources provide a set of laser beams not forming a common plane to a combiner which directs them into a planar arrangement wherein each of the laser beams is angularly spaced from the other and they all lie in a common plane.

It is a feature of the arrangement of the present invention that adjacent scanning beams scan non-adjacent lines on the drum 19 and thus permit scan overlap.

The combined laser beams exiting the combiner are telescoped to reduce the angular separation between them while providing beam expansion, after which they are deflected and focused onto photoconductive drum 19. The beams scan drum 19 by use of a hologon laser scanner and f-theta lens combination. Use of a hologon laser scanner reduces cross-scan errors which are normally introduced by the scanning device.

Referring now to Fig. 2, there is shown a schematic representation of marking engine portion 18 of the printing system shown in Fig. 1. The basic steps of the electrophotographic printing process can be described in terms of the functions of each of the components shown. A corotron 28 is used to provide electrical charging of photoconductiv drum 19 through high voltage corona

discharge. The photoconductive drum 19 is thus sensitized, and as it rotates in the direction of the arrow, it is exposed to the laser scanning beams to form an electrostatic latent image, since charge is dissipated in exposed areas. This is known as a "write white" technique, while the system may also apply the reverse "write black" technique.

The precise areas of exposure on photoconductive drum 19 are determined by the laser scanning beams, each component beam thereof being modulated by an acousto-optic modulator which can typically handle bandwidths of 30 Mhz. Using the multi-beam laser scanning system, the bandwidth of the system is easily increased over this to values upwards of 70 MHz average, and over 90 MHz instantaneous, allowing a concomitant increase in the information rate and the scanning speed for a given scan path length in the image plane.

Once photoconductive drum 19 has been exposed, continued rotation brings it into contact with image development station 30, where liquid toner is applied. The non-exposed areas of photoconductive drum 19 retain their charge and attract pigmented particles of the liquid toner to them, thus developing the latent image. A metering station 32 comprises a roller which rotates in a sense opposite to that of photoconductive drum 19 to shear off excess liquid toner and particles, leaving background areas uncontaminated.

As the developed image rotates into contact with paper 15, a transfer station corotron 34 provides paper 15 with an electrical charge to cause the developed image to transfer to it under the force of the electric field set up by the charge. Paper 15 continues to move in the direction of the arrows and the image is fixed by fuser 16 (Fig. 1) which fuses the toner particles together and onto paper 15. Completion of the printing process for one cycle occurs upon continued r tation of photoconductive drum 19 so that

residual toner particles are wiped off the drum in cleaning station 36. An erasure lamp 38 removes the remaining latent image by exposure.

Referring now to Fig. 3, there is shown a schematic representation of a preobjective hologon scanner 40 used to provide a focused scan line 42 on an image plane 44. Located in writing head 24, the hologon laser scanner 40 comprises a hologon disk 46 containing a plurality of diffraction gratings 48, a motor 50 and an f-theta focusing lens assembly 52. Arrow 54 depicts motion of the image plane, which corresponds to the direction of photoconductive drum 19 rotation.

An incident collimated laser beam 56 is provided by an optical system (not shown), and as hologon disk 46 rotates in the direction shown, a scanning laser beam 27 is produced. In the multi-beam laser scanning system of the present invention, incident laser beam 56 comprises a plurality of laser beams slightly separated in position and at angles with respect to each other and aligned in a common plane which is perpendicular to the plane of rotation of disk 46 and coplanar with the axis of rotation thereof.

The hologon disk 46 and lens 52 thus provide focused laser scanning beams 27 from incident laser beam 56. Use of hologon laser scanner 40 reduces cross-scan errors which are normally introduced by the scanning device and maintains the spatial and angular separation of the laser beams which comprise incident laser beam 56.

Referring now to Fig. 4A, there is shown a top view of an optical system layout for providing the multi-beam laser scanner constituting writing head 24 of Fig. 1.

In a preferred embodiment, writing head 24 uses four individual laser sources 62, 64, 66 and 68, all of which are mounted on a common optical bench 70 such that their respective output laser beams A1, A2, A3 and A4 are located in a common first plane, slightly tilted with respect to the plane of the drawing, with the axes f the lasers parallel

to the plane of the figure.

The laser sources may each be a He-Ne type having a 10 mW output each. Since the optical paths of respective beams A1-A4 are similar with regard to the optical devices contained therein, the following description of the optical path for beam A1 suffices.

Upon exiting laser source 62, lens 72 focuses beam A1 into an acousto-optic modulator 74 wherein beam A1 is modulated with information in accordance with an image to be printed or reproduced by the electrophotographic printing process previously described. While the preferred embodiment includes acousto-optic modulator 74, other possibilities include modulation of a continuous laser by an electro-optic modulator, by total internal reflection, or by use of light valves. Alternatively, a laser diode may be used to provide the modulated laser beam.

Upon exiting from acousto-optic modulator 74, modulated beam A1 is virtually collimated by a lens 76 and is reflected by a tilted mirror 78a. Mirror 78a reflects the beam in the plane of the figure so that it impinges on a combiner 80 and also introduces a tilt perpendicular to the plane of the figure, such that the beam A1 arrives at the combiner 80 at a small angle to the plane of the figure.

Each of the tilted mirrors 78a-78d corresponding to beams A1-A4 is tilted at a slightly different vertical angle from the plane of Fig. 4A such that the beams are incident on the combiner 80 at points which lie along an imaginary line perpendicular to the plane of the figure.

Vertical combiner 80 serves the purpose of combining the set of laser beams A1-A4 by reflection into a common plane 81 substantially orthogonal to the plane of the drawing. The tilt of mirrors 78 also provides that multiple beams 56 form a fan in the plane 81, with a fixed angle between adjacent beams.

In an alternative embodiment of the invention mirrors 78 do not provide any tilt ut of the plane of Fig. 4A, the

required tilt being provided by tilting the laser sources 62-68 as shown in Fig. 4B, which is a developed side view of the alternative embodiment. As in the first embodiment the beams are incident on the combiner in a spaced angular manner. For this second embodiment there is no common first plane of the laser sources. However, the combiner 80 combines the laser beams A1-A4 incident upon it into a planar fan of beams as in the first embodiment.

The alternative embodiment is illustrated in Fig. 4B, which illustrates a side view of the alternative embodiment of the optical system layout. Laser sources 62, 64, 66 and 68 are placed at slightly differing vertical heights and at slightly differing angles. The difference in vertical heights between two adjacent laser sources is typically 1 mm and the angular difference between two adjacent laser sources is typically 5 mrad.

In both embodiments, the vertically combined laser beams A1-A4 constituting incident beam 56 are then reflected by mirrors 82 and 84 into a telescope 86 comprising lens 88, iris 90 and lens 92. As shown in Fig. 4B, lens 88 is placed at the location of convergence of the beams A1-A4. It will be appreciated that at the convergence point, the angle between the beams is easily changed.

Thus, while telescope 86 expands the beams in order to magnify the beam spot size used for scanning purposes, it reduces the angle between the beams, reducing the sensitivity of the system to angular deviations of individual channels. A typical magnification provides a 35:1 ratio of input to output angular deviations.

Upon exiting telescope 86, incident beam 56 is reflected by mirrors 94 and 95 into hologon laser scanner 40 and f-theta lens assembly 52. Hologon laser scanner 40 operates to deflect incident beam 56 onto the image plane as laser scanning beams in accordance with the principles of operation previously described regarding Fig. 3.

Each of laser scanning b ams follows an ptical path

which is defined by reflecting mirrors 98 and 100 (see Fig. 6), to bring them into position for scanning along photoconductive drum 19 as shown in Fig. 2.

Turning now to Fig. 5, there is shown a perspective view of a vertical combiner 80 useful in the optical system layout of Figs. 4A and 4B. Vertical combiner 80 comprises a plurality of tiny mirrors 102, 104 106 and 108, one for each information channel as defined by beams A1-A4. Mirrors 102-108 are stacked upon each other and oriented about a central axis 110, each with a different horizontal angle as required to reflect the respective one of beams A1-A4 onto mirror 82.

As shown in Fig. 5, the construction of vertical combiner 80 enables it to combine laser beams A1-A4 from non-mutually planar spatially separated information channels into the common plane so that beyond mirror 82 their optical paths are aligned as incident beam 56.

In a further alternative embodiment of the invention, laser sources 72-78 provide a set of mutually parallel beams which are parallel to the plane of Fig. 4 and which have respective mutual separations perpendicular to the plane of Fig. 4 equal to the heights of mirrors 104 and 106 of Fig. 5. For this embodiment, the mirrors 102-108 are each tilted to provide the required convergence of the beams after reflection.

It will be appreciated by those skilled in the art that combiner 80 may have other forms where the optical configuration so requires, and that it may comprise a grating element, or an element having prismatic refracting or reflecting surfaces.

Fig. 6 shows not to scale a side elevation of the optical system layout of Fig. 4 viewed in the direction of arrows I-I, showing the subsystem comprising hologon laser scanner 40 and f-theta lens assembly 52. The optical path of the laser scanning beams is also shown as defined by reflecting mirrors 98 and 100, whereby beams A1-A4 are directed upward from writing head 24 for scanning along

photoconductive drum 19 as shown in Fig. 2.

Referring now to Fig. 7, there is shown a detailed schematic drawing of the laser-scanner focusing subsystem of Figs. 3 and 6. The major assembly components include f-theta lens assembly 52, hologon disk 46 rotating in housing 112, motor 50 and a motor driver 114. Incident laser beam 56 comprises beams A1-A4 which come from telescope 86 and which are reflected by mirror 94 (Fig. 4), so as to enter the rotating hologon disk 46 with the required angle. The output laser scanning beams 99 each of which is directed along the optical path previously described in connection with Fig. 6. As stated previously, the use of a rotating hologon disk 46 for a plurality of laser input beams A1-A4 maintains the vertical separation between them and reduces cross-scan errors.

Although rotating hologon disk 46 is used in the preferred embodiment for the laser scanning-focusing subsystem of Figs. 3 and 6, alternative embodiments include a rotating polygon mirror, galvo mirror or acousto-optic deflector.

Turning now to Fig. 8A, there is shown a perspective view of a staggered tracing pattern of the present invention for the scan lines on photoconductive drum 19 of the marking engine portion 18 of Fig. 2. In accordance with a preferred embodiment of the present invention, there is a small angular separation between individual laser beams A1-A4, illustrated in Fig. 4A, and a staggered tracing pattern is provided. In this fashion, individual laser beams A1-A4 do not trace neighboring image lines during a given scan. Instead, they trace image lines which are spaced apart from each other according to a predetermined sequence. This allows for the provision of overlap between the respective adjacent lines on the image.

If, as in the example provided herein, four laser beams are provided, drum 19 rotates at a speed such that it rotates four image lines for every scan. In a preferred

embodiment a first beam A may trace the first line of a given set of image lines, while the fourth line of the set is traced by a second beam B. The sequence of image lines traced in the first scan will thus be 1, 4, 7, 10 wherein the spacing of three image lines between the two beams A and B will be maintained for the remainder of the beams C and D constituting laser scanning beams 99. An alternative spacing of five image lines between scanning beams is also possible.

During each trace, the drum 19 is rotated by the spacing of the beams A-B. In the example given above, the drum 19 is rotated by the spacing of four image lines. Thus, the second trace of the example given above traces image lines 5, 8, 11 and 14.

Fig. 8B illustrates an example staggered tracing pattern of the present invention. The image lines traced by each of the four beams A-D are indicated according to the scan (first, second, third, etc.) in which they occur. It will be noted that full imaging does not occur until the seventh image line. Accordingly, traces corresponding to scan lines 1-6 are typically blanked out, or arranged to occur before the paper 15 reaches the scanning area.

It will be noted that the beam extent on the imaging surface is not a function of the line spacing, and thus by choosing proper beam expansion ratios, the scanned beams for adjacent lines will overlap even for focused beams.

For a given number of laser scanning beams N, a general mathematical expression for possible image line sequencing beyond the first scan line (which is always 1) may be written in terms of the resultant spacing as:

$$\text{line spacing} = (N - 1) + k \times N \quad \text{for } k = 0, 1, \ldots \qquad (1)$$

$$\text{or} \quad = (N + 1) + k \times N \qquad (2)$$

The preferred scan spacing is the smallest possible, such as given in the first example.

Thus for example if N=4, possible sequence for initial lines scanned by beams A-D is (equation 1, k=0, spacing equals 3): 1, 4, 7, 10 ; (equation 1, k=1, spacing equals

7): 1, 8, 15, 22; (equation 2, k=0, spacing equals 5): 1, 6, 11, 16; and (equation 2, k=1, spacing equals 9): 1, 10, 19, 28. In each of these cases if drum advances at a rate of 4 image lines per trace, then after a number of lines it will be found that all the image lines are traced.

It can be seen that the multi-beam laser scanner arrangement of the present invention achieves high performance in a compact arrangement. As applied to an electrophotographic printing process, large bandwidth capabilities and high speed, high resolution requirements are satisfied by a novel optical layout.

The present invention is not limited to what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined only by the claims which follow:

CLAIMS

1. A multi-beam laser scanning system comprising:

means for producing at least three non mutually planar laser beams;

multiple beam directing means receiving said at least three non mutually planar laser beams for providing a plurality of output beams which lie in a plane and have a fixed angular separation therebetween; and

means for providing a scanning motion to said plurality of output beams.

2. A multi-beam laser scanning system comprising:

means for producing a plurality of laser beams;

multiple beam directing means receiving said plurality of laser beams for providing a plurality of output beams which lie in a plane and have a fixed angular separation therebetween;

scanning means for receiving said plurality of laser beams and for providing scanning thereof across an image plane in a first direction, said plurality of laser beams being arranged such that multiple scans produce an interlaced scan pattern wherein no more than five scans are required to fill a field.

3. A system according to either of claims 1 and 2 and wherein said means for producing also comprises a plurality of acousto-optic modulator means, each of which is arranged for operation with a respective one of said laser beam sources.

4. A system according to claim 1 or claim 2 and wherein said means for producing also comprises a plurality of electro-optic modulator means, each of which is arranged for operation with a respective one of said laser beam sources.

5. A system according to claim 1 or claim 2 and wherein said means for producing also comprises a plurality of total internal reflection modulator means, each of which is arranged for operation with a respective one of said laser beam sources.

6. A system according to claim 1 or claim 2 and wherein said means for producing comprises a plurality of light valve modulator means, each of which is arranged for operation with a respective one of said laser beam sources.

7. A system according to claim 1 or claim 2 and wherein said multiple beam directing means comprises a combiner disposed so as to have each of said laser beams incident thereon at an individual surface thereof, whereby said laser beams are combined such that they are commonly aligned with a fixed angular separation therebetween.

8. A multi-beam laser scanning system comprising:

means for producing a plurality of laser beams;

means for separately modulating each of said plurality of laser beams;

holographic scanning means for receiving said plurality of laser beams following modulation thereof and for providing focused scanning of said laser beams across an image plane in a first direction, said plurality of laser beams being scanned lying in a plane perpendicular to the first direction and being arranged such that multiple scans produce an overlapping interlaced scan pattern.

9. A system according to any of claims 1, 2 and 8 and wherein said means for producing comprises continuous lasers.

10. A system according to any of the preceding claims 1, 2 and 8 and wherein said plurality of laser beam sources comprises laser diodes.

11. A system according to any of the preceding claims 1, 2 and 8 and wherein said means for producing comprises a plurality of laser beam sources aligned in a common first plane.

12. A system according to claim 11 and wherein said surface is prismatic and said modulated beams are combined by refraction.

13. A system according to claim 11 and wherein said surface is provided by a grating el m nt and said modulated

beams are combined by refraction.

14. A system according to claim 11 and wherein said combiner means comprises a plurality of mirrors.

15. A system according to claim 14 and wherein said plurality of mirrors are stacked vertically one upon another, one for each of said beams, each of said mirrors being oriented about a central axis with a different horizontal angle, such that said beams are combined as output beams in a single plane and have their optical paths aligned with one another for tracing the scanned lines in the image plane substantially without separation between them along the scan direction.

16. A system according to claim 11 and further comprising telescope means disposed so as expand each of said output beams and reduce said fixed angular separation therebetween.

17. A system according to any of the preceding claims 1 or 2 or 8 and wherein said scanning means comprises a hologon disk scanner and wherein said system also comprises focusing means including an f-theta lens.

18. A compact writing head for use in electrophotographic printing comprising:

an image bearing surface having a width of at least 30 inches; and

means for providing an image on said image bearing surface at a speed of at least 10 feet per minute with a resolution of 400 dots/inch including:

means for producing at least three non mutually planar laser beams;

multiple beam directing means receiving said at least three non mutually planar laser beams for providing a plurality of output beams which lie in a plane and have a fixed angular separation therebetween; and

means for providing a scanning motion to said plurality of output beams.

19. A compact writing head for use in

electrophotographic printing comprising:

an image bearing surface having a width of at least 30 inches; and

means for providing an image on said image bearing surface at a speed of at least 10 feet per minute with a resolution of 400 dots/inch including:

means for producing a plurality of laser beams;

means for separately modulating each of said plurality of laser beams; and

holographic scanning means for receiving said plurality of laser beams following modulation thereof and for providing focused scanning of said laser beams across an image plane in a first direction, said plurality of laser beams being scanned lying in a plane perpendicular to the first direction and being arranged such that multiple scans produce an overlapping interlaced scan pattern.

20. A compact writing head for use in electrophotographic printing comprising:

an image bearing surface having a width of at least 30 inches; and

means for providing an image on said image bearing surface at a speed of at least 10 feet per minute with a resolution of 400 dots/inch including:

means for producing a plurality of laser beams;

multiple beam directing means receiving said plurality of laser beams for providing a plurality of output beams which lie in a plane and have a fixed angular separation therebetween;

scanning means for receiving said plurality of laser beams and for providing scanning thereof across an image plane in a first direction, said plurality of laser beams being arranged such that multiple scans produce an interlaced scan pattern wherein no more than five scans are required to fill a field.

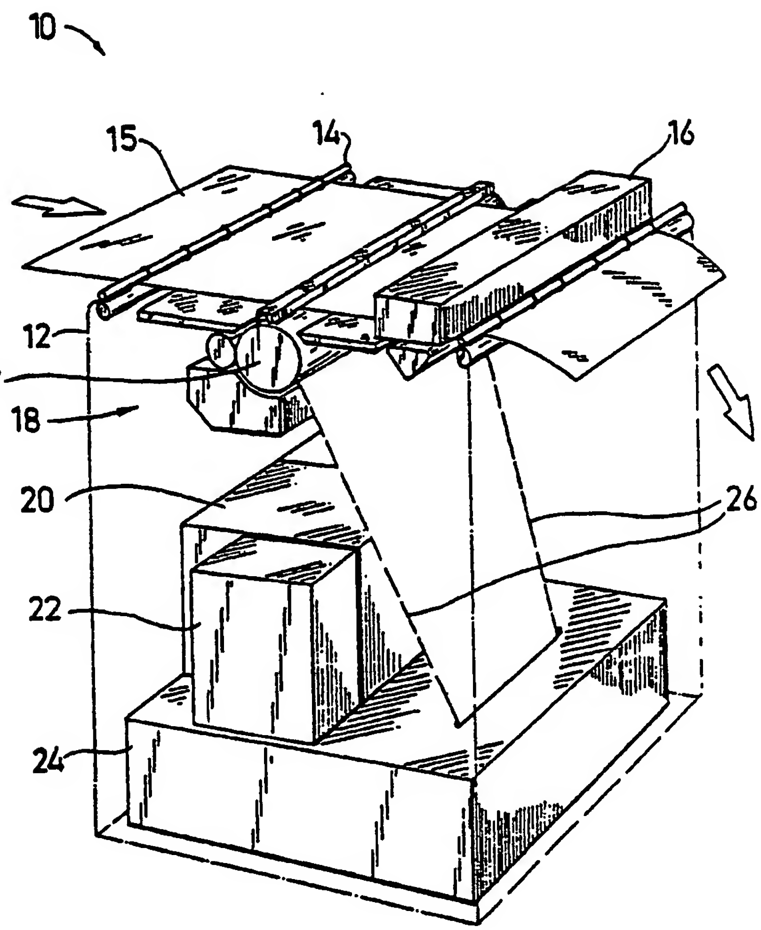


FIG.1

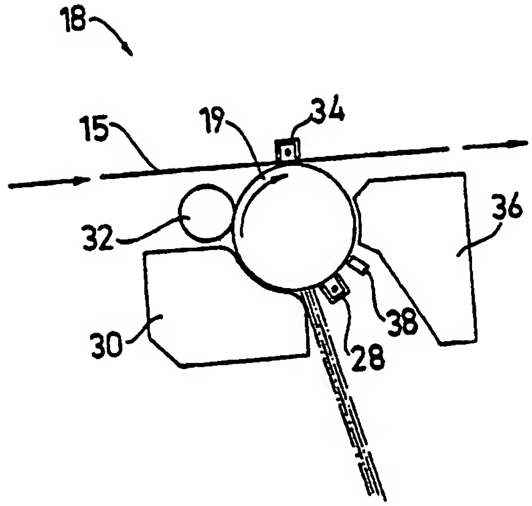


FIG. 2

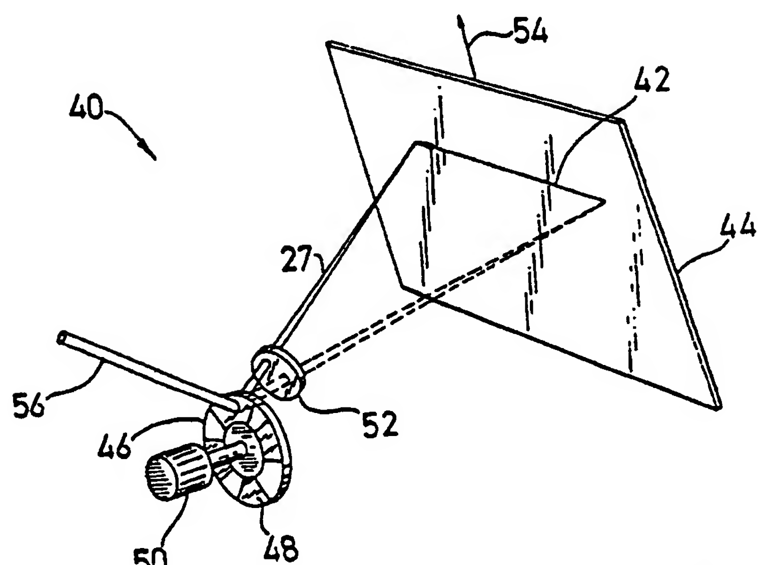


FIG. 3

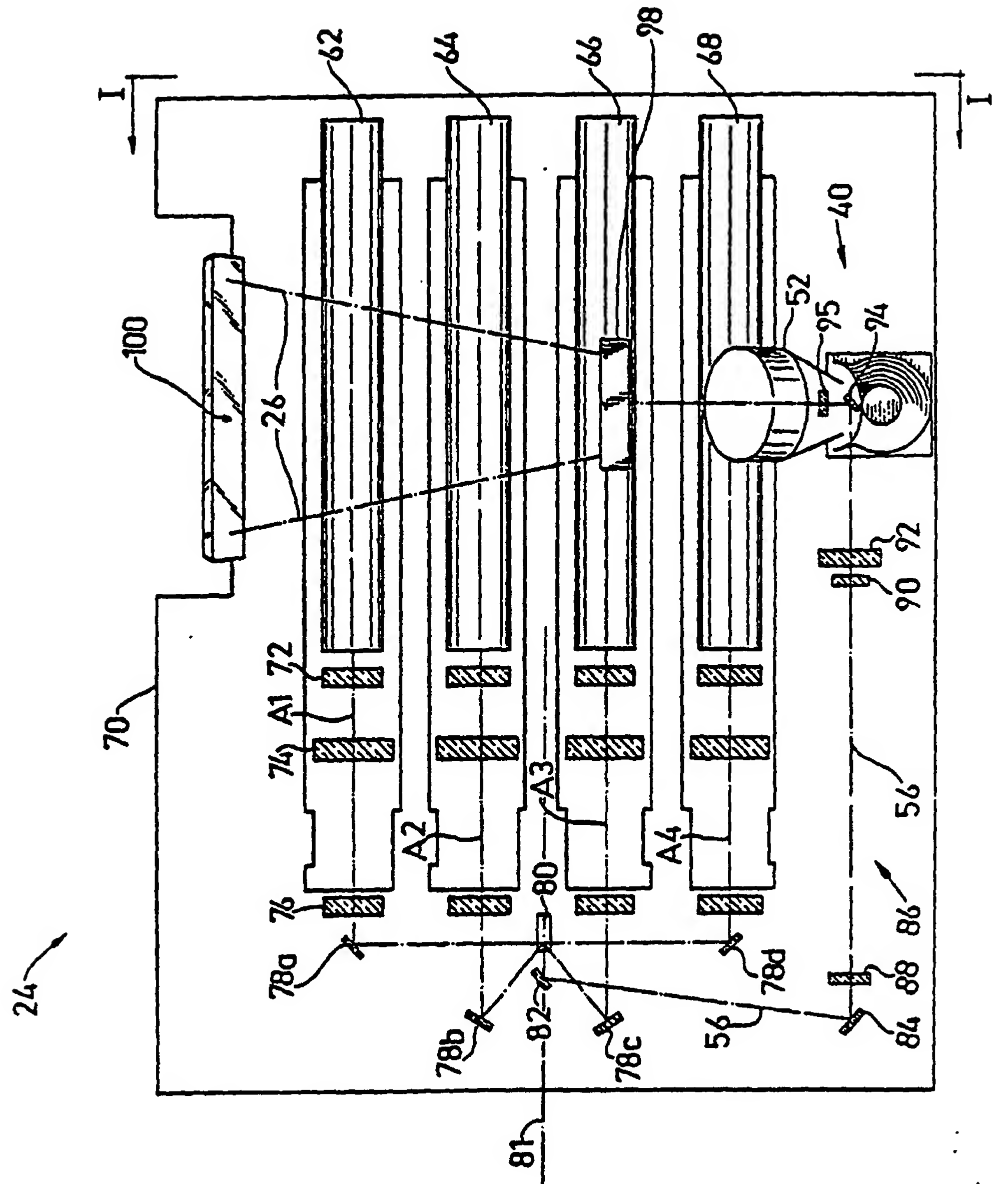

I
I
62
64
66
68
98
100
26
26
40
52
95
94
92
90
70
72
A1
74
A2
A3
A4
56
76
80
86
78a
78b
82
78c
78d
56
88
84
81
24

FIG. 4A

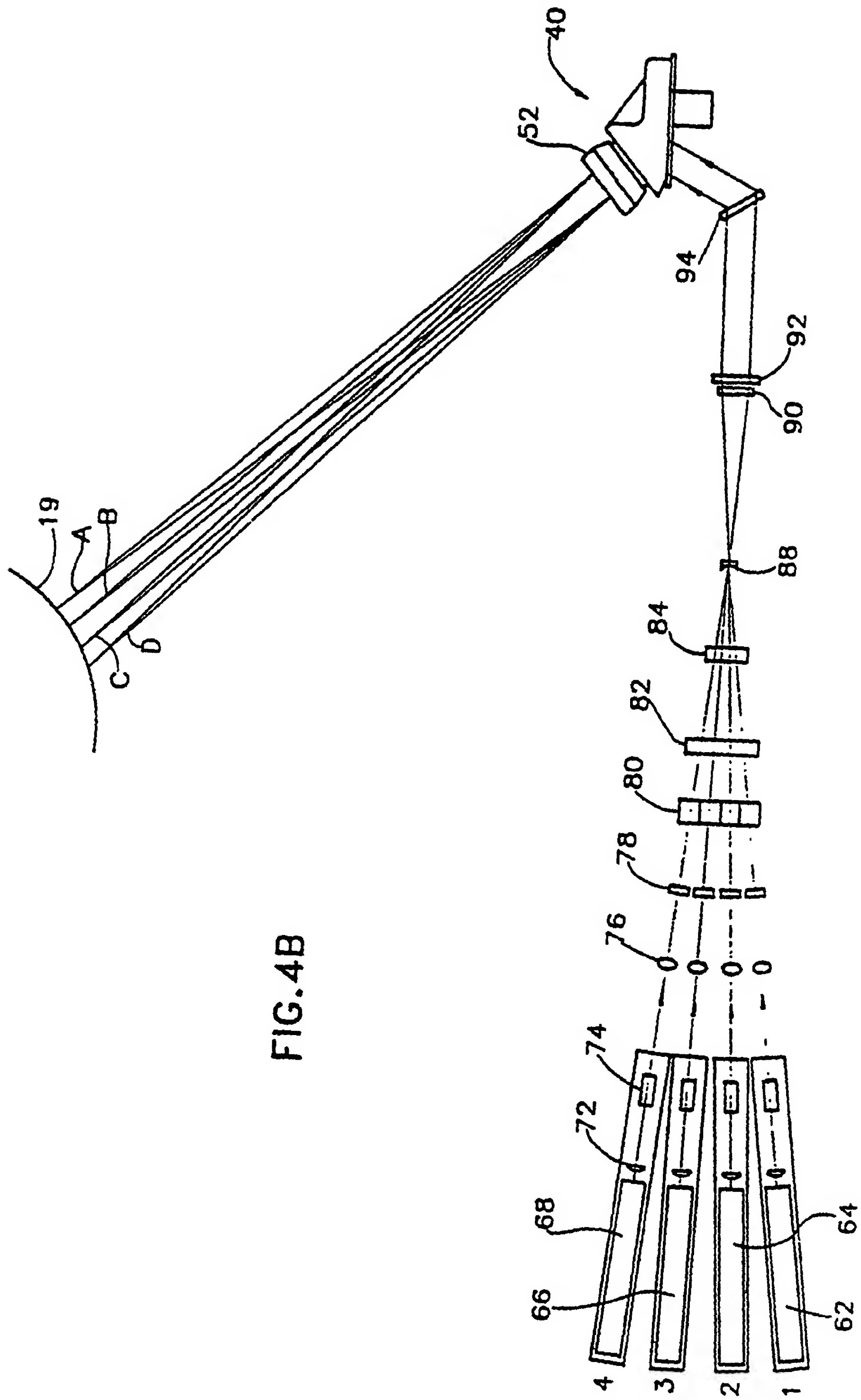


FIG.4B

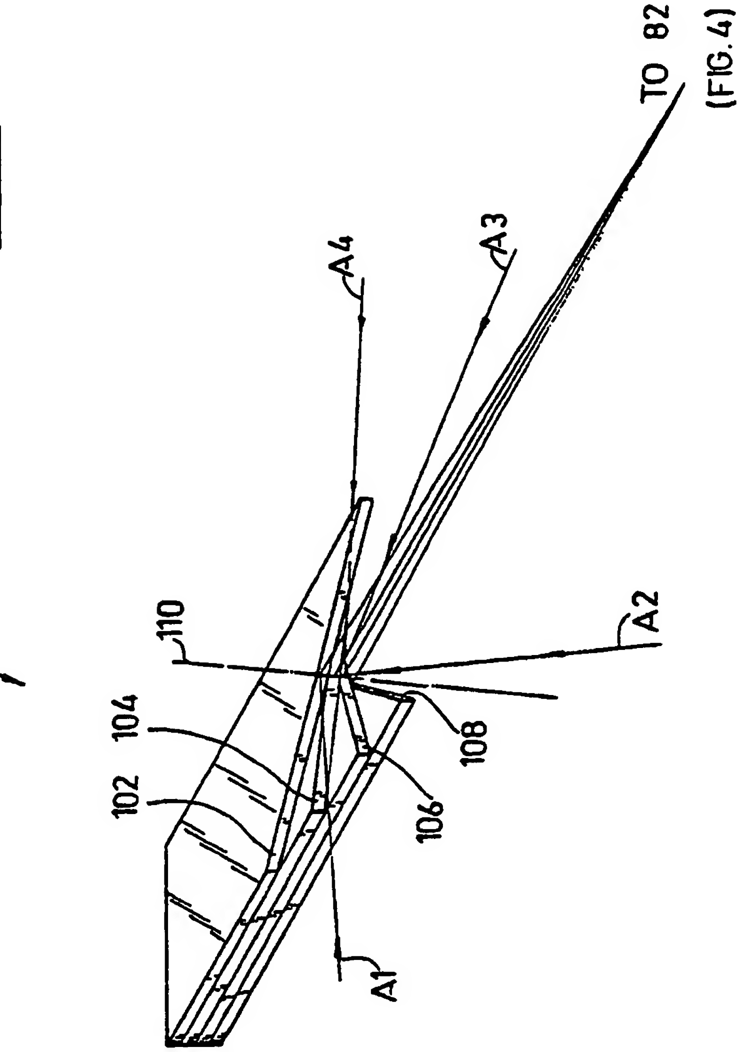
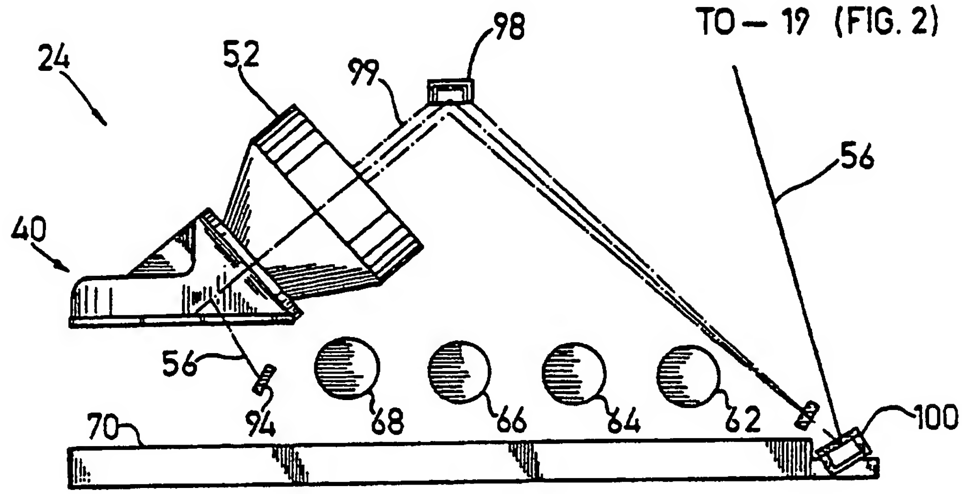


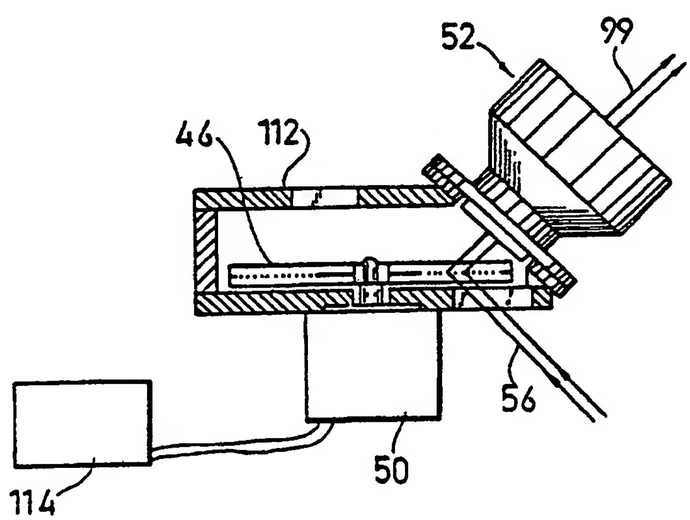
FIG. 5

FIG. 6



24
52
99
98
TO — 19 (FIG. 2)
56
40
56
94
68
66
64
62
100
70

FIG. 7



52
99
46
112
56
50
114

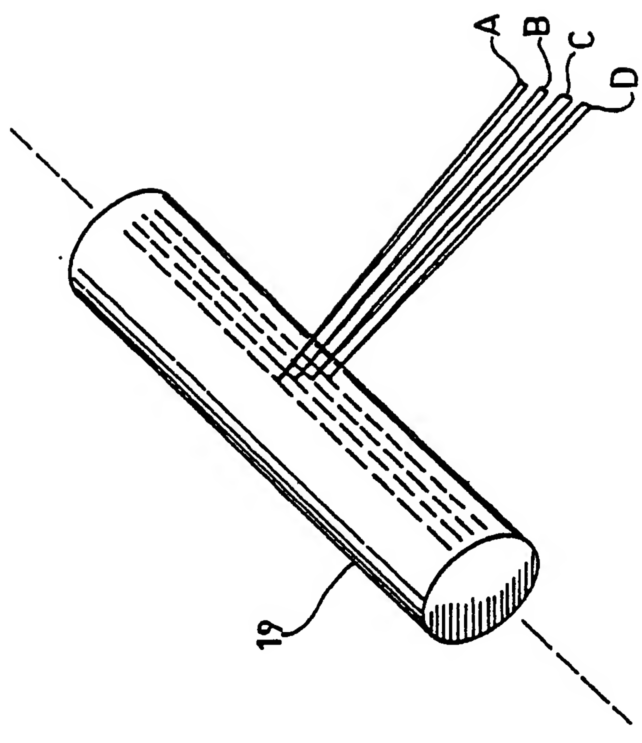


FIG. 8A

FIG.8B

IMAGE LINE	SCAN 1	2	3	4	5
1	A				
2					
3					
4	B				
5		A			
6					
7	C				
8		B			
9			A		
10	D				
11		C			
12			B		
13				A	
14		D			
15			C		
16				B	
17					A
18			D		
19				C	
20					B
⋮					

SCAN INACTIVE ↑

SCAN ACTIVE ↓

INTERNATIONAL SEARCH REPORT

International Application No PCT/NL 89/00043

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC^4: H 04 N 1/18

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC^4	H 04 N, G 02 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [*]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	EP, A, 0250132 (KONISHIROKU) 23 December 1987, see column 4, lines 19-30; column 25, lines 10-15; figure 30	1
A	..	2
Y	GB, A, 2169134 (CANON) 2 July 1986, see page 2, line 58 - page 2, line 86	1
A		2
A	US, A, 4401991 (MARTIN) 30 August 1983, see column 3, lines 1-17	2,8
A	GB, A, 2156624 (DAINIPPON) 9 October 1985, see the abstract	1-3
A	FKTG Fernseh- und Kinotechnische Gesellschaft e.V., Tagungsband, Manuskripte der Vorträge gehalten auf der 10. Jahrestagung der FKTG, 13. - 17. September 1982, München (DE) J. Helmberger: "Herstellung von Bildern durch Belichtung von	1-12,14, 15,17

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
22nd August 1989	22.09.89
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	L. ROSSI

Form PCT/ISA/210 (second sheet) (January 1985)

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category*	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
	lichtempfindlichen Schichten mit gesteuerten Laserstrahlen", pages 234-261, see the whole article --	
A	Patent Abstracts of Japan, vol. 8, no. 125, (P-279)(1562), 12 June 1984; & JP, A, 5929221 (RICOH K.K.) 16 February 1984 (cited in the application) --	8,10,11,17
A	EP, A, 0021852 (XEROX) 7 January 1981, see claim 1 & US, A, 4304459 (cited in the application) --	8,11,13
A	US, A, 4445126 (TSUKADA) 24 April 1984, see the abstract --	1,11,16
A	US, A, 4303936 (SHAW) 1 December 1981, see column 2, lines 42-46 --	18-20
A	WO, A, 86/07640 (BYCKLING et al.) 31 December 1986, see page 9, line 13 - page 11, line 6	18-20

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

NL 8900043
SA 29197

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 15/09/89
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		CA-A- 1128789	03-08-82
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US-A- 4303936	01-12-81	None	
WO-A- 8607640	31-12-86	DE-T- 3690327	06-08-87
		GB-A- 2188444	30-09-87
		JP-T- 63500897	31-03-88

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